appeared to be black, and the motion either corkscrew like or snake-like, with vertical undulations. Three of the observers have since made sketches from memory, quite independently of the impression left on their minds, and on comparing these sketches, which slightly varied, they have agreed to sanction the accompanying outline as representing as nearly as possible the object which they saw. The party consisted of W. Barfoot, J.P. of Leicester, F. J. Marlow, solicitor, of Manchester, Mrs. Marlow, and several others. They discard the theories of birds or porpoises as not accounting for this particular phenomenon.

F. T. MOTT

Birstal Hill, Leicester, January 16

A Novel Experiment in Complementary Colours

THE old maxim of an *adjacent gray* in order to give visibility to a complementary colour seems to hold its ground. Mr. Charles T. Whitmell puts it very clearly when he alludes to "the advantage of a reduction of brightness to a level comparable with that of the existing colour."

Mr. Whitmell will find, I think, that this brightness may be still further reduced below the level of the existing colour. This may be shown by one or two remarkable experiments with light admitted through a small needle hole the one-fiftieth of an inch in diameter, made through the bottom of a half ounce pill-box painted inside with lampblack. On placing a sheet of white paper on the table at night in a room lighted with ordinary gas, and looking through the small hole with one eye, *both eyes being open*, he will see on the paper a disc of a beautiful cobalt *blue* colour, evidently the complementary of the yellow light of the gas. On examining the sky in the same way in the morning, there will be seen, especially if the weather is dull and hazy, as it has been of late, a disc of a *primrose yellow* colour, the complementary of the blue sky, which, although invisible, is still making its impression on the sensitive retina. Later on in the day, between five and six o'clock, when the weather is murky, the disc has a well-marked *pink* colour, the atmosphere being evidently tinged with dark green. These several results I have witnessed from day to day for the last fortnight, and they have been verified by others to whom I have shown them. But when the sky is very blue and clear, there is seen, for obvious reasons, a blue disc only.

In the above experiments there is the curious anomaly of having one eye impressed with the exciting colour, the other with its complementary.

JOHN GORHAM

Bordyke Lodge, Tunbridge, January 20

The Projection of the Nasal Bones in Man and the Ape

IN my letter in the last number of NATURE (p. 266) the walls of the human nose were carelessly ascribed to the elevation of the *pre*-maxillary bones. This is not the case. It is only in the ape and lower animals that the ascending processes of the premaxillary assist in forming the external nose-case, or muzzle, *above* the nostrils. The frame-work of the nose in the lower types of the negro seems, therefore, in this respect, to differ more from the nose-case of the ape, than it does owing to any great development of the nasal bones.

I take this opportunity to mention that the woodcut of the embryo, which I referred to, appeared first in Quain's "Anatomy." Also, the quotation about the nasal bones of the orang, I have since found from my notes, to have been derived from Prof. Mivart's "Man and the Ape."

January 22 J. PARK HARRISON

HOVERING OF BIRDS

THIS problem, to account for the phenomenon of the motionless hovering of hawks and other birds in mid-air, was the subject of correspondence in NATURE, vol. viii. pp. 86, 324, 362; vol. ix. p. 5; vol. x. pp. 147, 262: vol. xi. p. 364. The only plausible explanation advanced (by Joseph Le Conte, vol. ix. p. 5, and previously by the present writer, vol. viii. p. 362) was that the birds take advantage of slant upward currents of wind sufficiently strong to neutralise the force of gravity. But the arguments brought forward in support of this explanation were perhaps not quite conclusive, for lack of a sufficient series of observations.

During the past six years I have noted such instances as I have chanced to witness in the course of a wandering occupation, and now offer the results as a further contribution towards the solution of the question.

I may state at once that in every case where I have seen a bird hovering, the following three conditions have obtained:—

(1) There was a fresh wind blowing.
(2) The bird was facing the wind.
(3) Beneath the bird there was a steep slope of ground facing the wind.

The particular localities in which I have observed the phenomenon are the following:—

(1) 1877, *September* 17.—Driving from Aberayron to Llanrhystyd (Cardiganshire). Wind W.N.W., moderate. Cliffs facing N.W. Gulls under cliff top, below road, in poise. Hawk under hill top, above road, in perfect poise.

(2) 1877, *October* 13.—Approaching Llantrisant town (Glamorganshire) from Llantrisant Junction. Wind S.W., moderate. Hawk over S.W. slope, barely poising, partly fluttering, tail plainly brushed up.

(3) 1877, *October* 14.—Llantrisant (Glamorganshire). Wind S.S.W. Rooks upborne, above S.S.W. slopes of hill with entrenched fort (Caerau).

(4) 1877, *October* 20.—Cliff facing S. between Longland and Caswell Bays, Gower (Glamorganshire). Gull and crows upborne. Wind moderate, S.S.W.

(5) 1877, *October* 21.—Cefn Bryn, Gower (Glamorganshire), facing S.S.W., climbing from Reynoldston. Rooks upborne. Wind strong, S. by W.

(6) 1879, *October* 17.—On road from Llantrisant to Pontypridd (Glamorganshire). Wind W. Rooks upborne over slopes facing W.

(7). *October* 28.—Killay, near Swansea (Glamorganshire). Hawk poised above hill-side facing N.E., to the west of Killay railway station. Wind N.E. I was almost under the bird, and could see the conduct of wings and tail suiting the ripples of wind.

(8) 1879, *November* 5.—Near Merthyr Tydfil (Glamorganshire). Hawk poised over N. slope of hill above (to S. of) tunnel on Merthyr-Abernant Railway. Wind N.

(9) 1880, *March* 13.—Near Penally (Pembrokeshire). Sea-gulls, rooks, and jackdaws upborne and floating with wings outstretched all along cliff line facing S., between Penally and Lydstep. Wind S., full on cliff from the sea. Gulls up to 200 feet above cliff edge. At greater height and inland, they were flapping. Different behaviour of rooks over inland northern slope.

Further on, over caves at north end of Lydstep Sands, hawk poised for 1 min. and 1½ min. at a time, just over cliff line, in teeth of wind off sea.

(10) 1880, *March* 17.—Near Cardiff (Glamorganshire). Hawk poised about 10 or 12 feet above railway embankment facing E.N.E. (20 or 25 feet high) of Llandaff and Penarth line, near Ely Station. Wind E.

(11) 1880, *March* 27.—Gulls uplifted over E. scarp of Beachy Head Down (Sussex). Wind E.N.E.

(Same day).—Over N.E. slope of Lighthouse Down. Bevy of eight gulls, all in perfect poise, immediately over edge of cliff.

(12) 1880, *August* 8.—Wells next-the-sea (Norfolk). Wind N.W. Hawks poising over W. slope of sea-wall, and over N.W. slope of sand-hills (projecting from the main line of dunes that runs east and west), and trying unsuccessfully over railway embankment which runs N.W. and S.E.

In several of the instances here recorded I was near enough to see that the bird was delicately adapting the slope and spread of its wings to the momentarily varying inclination and force of the wind. Among the sand-hillocks near Wells, on the Norfolk coast, I succeeded in approaching, under cover of ridges and long grass, within about ten yards of a hovering hawk, and saw the

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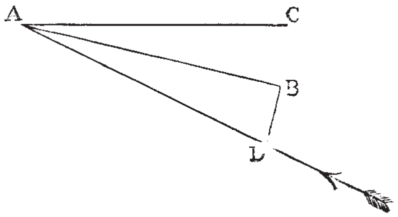
posture of the bird very well for a few seconds, till he became aware of my presence and dashed away. I was much struck by those instances in which the obstacle that caused the upward slant of the wind was only a sea-wall or a railway embankment, and especially by the critical case (No. 12) where the bird was evidently baffled because the wind lay along the embankment, not against it, and therefore gave no upward current.

My list includes four cases (3, 4, 5, 6) of rooks and gulls "up-borne" on outspread wings, under conditions similar to those present in hovering—cases that could not be explained by any theory of *vis viva*, but clearly involved an external mechanical force, which could only be that of the wind, sustaining and uplifting the birds. The close relation between the "up-borne" and the "hovering" action was evident in case (9) where the gulls, &c., were up-borne and sailing, while the hawk was poised and motionless.

These observations, as far as they go, appear to indicate plainly the law which governs the phenomenon in question. I think they strongly confirm the theory already advanced, that the bird in hovering is upheld by a slant upward current of air. A strong wind pressing against a slope of ground is necessarily thrown into a slant upward current, "as slopes a wild brook o'er a hidden stone." There may be a downward eddy if the slope is precipitous, as one may often feel at the foot of a high wall, but the main stream of the air for some considerable height above the slope is forced to take an upward slant, with increased velocity, in order to surmount the obstacle in its path.



Given such a slant upward current, it is easy to see that a bird, with the exquisite muscular sense that every act of flight demands and denotes, might so adapt the balance of its body and the slope of its wing-surface to the wind as to remain motionless in relation to the earth. The slope of the wing-surface should divide the angle between the horizontal and the direction of the slant wind-current in such proportion that, if the air were at rest, the bird, under the action of gravity, would float forwards, downwards, on outspread wings, with exactly the same velocity as that of the wind (in which it remains motionless) and in exactly the opposite direction. The mechanical conditions are identical in the two cases, whether we consider the air at rest and the bird floating through it, or the bird at rest and the wind rushing under it. In either case the bird has reached, and maintains, its maximum velocity, due to gravity, compatible with the resistance of the air, which resistance is the same in both cases.

I have heard it objected that the mechanical conditions are not the same in these two cases, because in the one case the bird has momentum, in the other not. Need it be said that momentum is a purely relative possession, just as velocity is? In each case the bird has the same velocity, and therefore the same momentum, relative to the air. The mechanics of the situation, as between bird and air, are not affected by the possession or loss of velocity (and with it momentum) relative to the earth.

Perhaps the feasibility of the thing may be best shown by a simple diagram. Let AB represent the slope of the bird's wing (viewed from the right side), dividing the angle between the horizontal, AC, and the direction of the wind, DA. Draw BD at right angles to AB, and take AD to represent the force of the wind. Then DB and BA will represent the force of the wind resolved perpendicular and parallel to the slope of the wing AB. The resolved part, BA, meeting only the resistance of the bird's head and shoulders and front edge of the wings, tends not strongly to push the bird in the direction, BA, that is, backwards and a little upwards. But the resolved part, DB, which meets the full area of the outspread wings and tail, tends powerfully to push the bird in the direction DB, that is, upwards and a little forwards. Then all that is required to keep the bird at rest is that the effect of the forward force exerted by DB should balance the effect of the backward force exerted by BA (both being resolved vertically and horizontally), and that the great upward force exerted by DB, together with the small upward force exerted by BA should exactly neutralise the downward force of gravity.

The only difficulty in the way of the slant-upward-current theory lies in the statement of the Duke of Argyll (NATURE, vol. x. p. 262) that "a hundred times" he has seen birds hovering "when by no possibility could any upward deflection of the wind have arisen from the configuration of the ground." My own observations testify so consistently in favour of slant upward currents that I feel justified in asking for more precise information concerning the instances alluded to by the Duke of Argyll, before relinquishing the theory which I hold. Wherever I have seen a hawk trying to remain in one position over a plain or slightly undulating ground, the feat has only been accomplished by continued vibration of the wings.

The problem of the "soaring" of birds introduces other conditions, which require separate consideration, though I believe it will be found that the two phenomena of "soaring" and "hovering" depend upon essentially similar causes.

(By the bye, does not the provincial name of one of the hawks, the "Windhover" record the constantly observed dependence of the act of hovering on the wind?)

HUBERT AIRY

THE LATE EDWARD B. TAWNEY

By the death of this young naturalist English geology has lost one of its most enthusiastic and cultivated students. Hardly beyond the threshold of his career, he had already gained for himself a notable place among the geologists of this country, and his friends augured for him a future of distinction and usefulness. But in the fulness of his promise and in the midst of his work he has been struck down so suddenly that few of his friends knew he had been ailing until they were shocked and saddened by the news of his death.

Born in 1841, he was the third child of the Rev. Richard Tawney, Vicar of Willoughby, Warwickshire, who had gained a distinguished place at Rugby, and had been a Fellow of Magdalen College. On the death of his father, young Tawney was placed under the care of his guardian, Dr. Bernard of Clifton, and received his early education there. During these years he seems to have acquired a bent towards natural science mainly through the influence of Dr. Bernard and Dr. Fox of Brislington. He was eventually enabled to gratify this inclination by attending the courses of instruction at the Royal School of Mines, Jermyn Street, from 1860-63, where he greatly distinguished himself. He gained a Royal Scholarship, Duke of Cornwall's Scholarship, the De la Beche Medal for Mining, and the Edward Forbes Medal for Natural Science, and took Associate's diplomas in the Mining and Geological divisions.

With the training in scientific methods thus obtained, he soon betook himself to original research, gaining experience by excursions at home and by travel abroad. In 1872 he accepted the offer of Assistant Curator of the

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